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USES AND ABUSES OF NEUROSCIENCE TECHNOLOGY IN THE COURTROOM "I did not do it, it was my brain..."

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Abstract: Classic evidence admitted in the courts of justice has obvious limitations, especially because of the low reliability of eyewitness memory. For many years, neurological diseases have been considered when estimating the responsibility and imputability of the defendants. However, with the emergence of neuroscience and neurotechnology in the last 20 years, the contribution of tests based on brain diagnostic techniques has increased exponentially with different purposes: attenuation or exoneration criminal responsibility, validation of witnesses, recognition of physical evidence and crime scene, acceptability of the members of the jury, etc. In this article we propose a review of the scientific evidence that may or may not support these applications of neurotechnology in courts, as well as the ethical and legal implications that this new paradigm may imply.

Keywords: *Ethics, Human Behavior, Justice, Neurolaw, Neuroscience.*

INTRODUCTION

The availability of images from Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging, (fMRI) has led to the proposal to draft a brain map to explain the functioning of the mind and its implications on human behavior. However, this does not mean that neuroscience attains the status of "supreme law" as the only tool to substantiate human morality or behavior. Neurosciences, and especially brain imaging techniques (through the power of visual stimuli to generate "evidence" in the human mind), require special rigor in their procedures and interpretation of results. An interpretation of these results based solely on their "showiness" can generate risks or, at least, scientific futility.

Until relatively recently, it was only possible to access the dead human brain. However, new neurophysiology and neuroimaging technologies have allowed to study the structure and brain function in living brains. Consequently, we are gradually changing the way we see ourselves as the use of these new technologies to explain human behavior even calls into question the intuitive idea of free will, exempting us from moral responsibility. This notion of responsibility is at the core of our ethical and legal systems. Therefore, neuroscience could promote a new moral paradigm in which if we are not responsible for our behavior, is it our brain or our neurons responsible for it?

The aim of this article is to review the contributions and possible impacts (ethical and legal) from different perspectives (neurology, law and philosophy) of the introduction of neuroscientific technologies in a very specific applied field of social life: the court of justice. Are neurophysiology or neuroimaging useful tools for preserving justice? And if they are so to a certain extent, are we using and interpreting them correctly?

THE CASE OF MR. WEINSTEIN

One clear example of the danger of misinterpretation can be seen in the introduction of neuroscientific technologies as evidence in the courtroom. In a murder trial held in 1992 in New York, the accused had strangled and thrown his wife from the twelfth floor of a building. (1) A PET test and Magnetic Resonance Imaging (MRI) of images suggestive

of an intracranial arachnoid cyst were presented as evidence for the defense: this is a frequent finding in clinical neuroimaging that is asymptomatic in the vast majority of cases and, of course, does not have a link with criminal behavior as described in scientific literature.

Although this could have remained as a mere anecdote of irrelevant evidence in an attempt by the defense attorney to exculpate the accused, it caused the jury, despite the contrary opinion of the experts consulted, to issue a verdict of involuntary manslaughter, in the light of the showiness of the neuroimaging, arguing that he did not act within normal biological parameters.

It should be noted that, firstly, law seeks to guide human behavior towards a socially accepted conduct and settle conflicts that derive from it. Secondly, neuroscience seeks to describe the mechanisms of the brain, which is the biological basis of behavior and mental states. In this context of cooperation between these disciplines, it could be understood that neuroscience wants to tell the law "do not worry, I interpret the behavior".

In fact, the use of scientific concepts in court proceedings is not new. Psychology and psychiatry have provided trials with behavioral surveys for decades now; sociology contributed by defining the framework of criminal justice (punitive, consequentialist, rehabilitative) and economics exported analysis models to conflicts such as grievances or unfair competition.

AN INTELLECTUAL EXPOLIATION OF SCIENCE?

Another important factor when talking about this subject is the risk of progressive intellectual devaluation of science in that it can be devoured by applied techniques and Information and Communication Technologies (ICT), producing news, patents and prejudices before generating knowledge. Neurotechnology is being used in courts for the purposes of providing evidence for lack of intent or diminished responsibility. (2) Technological advances are always suggestive in the eyes of the law and have considerable potential, but would benefit from an interdisciplinary approach. In the same way that the validation of the law is also subject to a moral consensus to legitimize legal authorities, (3) neurosciences and the law must understand that its validation is also subject to a social context that will determine its legitimacy in the criminal field.

In 1923 the lawyers of J. A. Frye, accused of murder, demanded that their client be subjected to a truth test based on systolic blood pressure (a clear antecedent of the polygraph or lie detector), to determine his guilt; however, the judge refused to perform such a test claiming that the technology had not established itself as sufficiently reliable. (4) Table 1 shows some similar cases. The most frequently used techniques are brain imaging and/or neurophysiological tests, but genetics or psychopharmacology have also been invoked in certain trials. In many cases, the evidence supported penalty reduction (↓), if not cancellation (Φ).

New technologies generate attitudes that are, on the one hand, reckless ("technophilic") and, on the other hand, puritanical ("technophobic").

Table 1. Examples of trials when neurotechnologies have been used as evidence and/or validating testimonies. (5) (6)

Case	Tried crime	Pathology	Technology	Objective
2009, Dugan	Rape + murder (x3)	Psychopathy	fMRI	↓ punishment
2009, Albertini	Attempted murder parents + sister burned alive	Impulse control disorder	RMI (grey substance volume in anterior cingulate)	↓ punishment
2009 (Trieste)	–	Genetic tendency to aggressiveness	Genetic test	↓ punishment
2009, Thomas	Murder of spouse	Parasomnia	Neuro-Pharmacology Studies	Φ punishment
2010, Lorne	–	–	fMRI (lie detector)	Veracity of their testimony
2011, Nelson	–	–	RMI electroen-cephalography	↓ punishment
2013, O'Connor	Gambling with secondary debts	Tumor	RMI	Φ punishment
2013 (Venice)	Pedophilia	Tumor	RMI	↓ punishment
2014, Halvarsson	Rape	Sleep sex (sleepwalking)	Sleep study	Φ punishment

It is therefore a question of avoiding undue uses and promoting legitimate uses of neuroscience in the legal world. Thus, the only way to achieve these goals is through transdisciplinary reflection (what is done between disciplines but goes beyond the disciplines). (7)

Obviously, the application of neurosciences in criminal proceedings has provided new opportunities, especially when it comes to providing mitigating and/or exculpatory evidence for crimes. It should also be noted that due to the spectacular nature of fMRI presented as evidence, many times the findings are accepted uncritically, without questioning whether it can explain an alteration in the behavior of the accused (technological fascination). This phenomenon is known as the *fallacy of novelty* or *appeal to novelty*, consisting of the assumption that new technologies are invariably better than the old ones, based exclusively on their newness. (8) In recent years, there have been many studies questioning the validity of the results obtained with this technology as "objective evidence" for different reasons. (9,10)

In this respect, one could argue that this technological addition to the courts is disordered, unsystematic, lacking a solid theoretical base and insufficiently contrasted. These possible misuses can entail a risk of damages and injustice related to evidence admission, imputation (or not), modification of penalties, etc.

NEUROLAW

It is clear that the currently accepted methods (behavioral) used as evidence in legal proceedings are not "perfect", precisely because of the low reliability of eyewitness memory, as well as the inability of psychiatry to categorize certain states or behaviors with high degrees of reliability. For this reason, neurolaw presents itself in a multidisciplinary field, which is rapidly developing, and tries to analyze carefully the ethical and –especially– legal implications of developments in neuroscience. Due to the rapid advance of these technologies and their potential to be applied to the criminal field, it begs the question of whether we can determine the guilt of a person by "reading" their mind. What if this "reading" betrays their testimony? What really constitutes "intention" to kill?

These issues must be addressed from a point of view that is not fascinated by the new neuroscientific discoveries that project the responsibility of a criminal act onto the minds and not onto people, known as *Brain*

Overclaim Syndrome (BOS); (11) proceeding with this prejudice can lead to futile, erroneous and unfair uses. With this in mind, we must ask ourselves what questions we want to answer with the help of the machine.

On the one hand, regarding the accused, we want the machine to determine whether individuals decide with capacity and intentionality, that is, if they are responsible. Also, we want to know what their mental state is and if they are telling the truth. We can also check whether they remember things, people or facts related to the act being judged, regardless of whether they are aware or not. Or if there is a risk of recurrence in committing the crime, and whether there is any chance of reducing this risk, either through treatment, rehabilitation, psychotherapy, brain development, or the spontaneous evolution of a hypothetical disease. On the other hand, we also want to ask questions regarding the sensitivity of jury members, who will be most likely to punish the crime or its attempt, whether they are rather cold and rational rather than emotional in their decisions. Currently, the jury can be selected by fMRI depending on their decision-making in experimental models of moral or legal dilemmas (more emotional or more rational, more sensitive to intention or act).

In this sense, the task of the jury is to determine three states: I) whether the defendant committed the act ("*actus reus*"), II) his/her awareness ("*mens rea*") and III) responsibility. That is, whether the accused actually committed the acts attributed to him/her ("*actus reus*"), in such a way that the jury become amateur "mind readers", deciding whether the accused possesses a guilty mind ("*mens rea*") and determining what degree of responsibility they attribute to the accused: e.g., intentional, "aware", reckless or negligent.

Can neuroscience help in this difficult task? It might help, but we should be aware of its limits. Credibility assessment ("*actus reus*" and "*mens rea*"), can be carried out by detecting lies and eliciting memories. The intentionality of the actions of individuals depends, among other things, on their pathologies and mental states, which can modulate the adjudication of criminal responsibility; namely, we are talking about the cognitive control capacity of teenagers, certain neurological disorder patients, or people subjected to neuropharmacological effects. Evaluating decision-making process criteria (emotional/rational, intention/outcome, etc.) can also be used to select and/or reject jury members, and to detect and/or reduce biases. The establishment of predictions of risk of recidivism to define an appropriate penalty and to prevent new crimes has even been proposed. Nevertheless, many social determinants are involved in this

risk, and it seems very difficult to obtain a reliable "criminal prediction" using only neuroscientific data.

However, we must bear in mind that neuroscience is at a certain distance from law, so a precautionary attitude should be maintained when dealing with issues that touch both disciplines. It is people, not brains, who decide, know, do (act), etc., (12) and legal criteria refer to behavior. (13) The fact that these criteria are now accepted does not mean that they are ideal. Rather, there are often weak points or gaps that legal professionals try to solve through legal reasoning, and we can explore whether neuroscience might help in this endeavor by improving these criteria.

It is crucial that the law listens to neuroscience, and that neuroscience seeks to understand the law. No statements of a legal nature can be made by neuroscience if the experiment on which it is based has not been designed taking the "consensual" legal concepts into consideration and using compatible language. However, the law must be willing to reinvent itself in view of these "facts".

THE ANTHROPOLOGICAL CHALLENGE: A NEW MODEL OF HUMAN BEING?

Despite not having a clear epistemological concept of volition (will), humans have an intuitive perception regarding intentionality and free will. The law starts from this premise of mind autonomy to generate most of the legal principles based on responsibility. Thus, the idea that a large part of our behavior, moral and immoral, is only caused by physical brain processes (supported by some neuroscientists) is a challenge to this intuition. But the debate about free will is ancient and has not been generated by modern neuroscience. Spinoza argued that "man's perception of freedom is simply ignorance of the causes of his action". (14) Therefore, according to Spinoza, human behavior is determined.

Later, Lombroso said: "criminals do not commit crimes outside their own will, but are urged to commit crimes by their innate and primitive organic nature". (15) His criminological theory asserts that delinquency stems from an individual's abnormal physical constitution, therefore they are not responsible for their behavior and must be kept in conditions which prevent them from posing a threat to society.

With respect to a constructivist view, Hegel commented that free will is a "thinking" will. Put simply, Hegel maintains that the essence of the

will is action, understood as a change in the caused world, not just by chance, but by a certain intentionality and causation-by-agent. (16) This reflection is of great importance to neurobiology, because the Hegelian arguments concerning free will would be, to some extent, tested and observed in the laboratory.

From a current perspective, the physicist and philosopher of science Mario Bunge distinguishes two ways of understanding freedom. (17) On the one hand, there is negative freedom (freedom from all restrictions) that can never be complete, since we are always conditioned by the social and natural environment. And on the other hand there is positive freedom (freedom to act) that is possible and compatible with determinism. This is because our areas of volition (located in the frontal lobes and the parietal cortex) intervene to exercise it.

Asking ourselves "Do we have free will, or merely options?" "Do we act, or does our brain?" "Do neurons have responsibility?", would lead us to speak of determinism. Is free will only an illusion? Under these premises, reflections on "what should I do?" or "why should I do it?" would be a trivial issue and the moral conscience would not exist. Therefore, there would be no legal responsibility attributable to a voluntary act, in the way we understand it nowadays. (18)

In fact, the formulation of determinism is so powerful because of its apparent simplicity. Its basis is the idea that the brain determines the mind and that it is a physical entity. In this way, the brain is subject to all rules of the physical world. As the physical world is determined, so must be the brain. Therefore, all human action is inevitable and there is no choice or decision. However, the proposition that "the physical world is determined" admits, at least, scientific and philosophical deliberation.

Universal physical laws seem too abstract to shift the intuition of the concept of personal responsibility to our minds. However, at the same time, we intuitively tend not to hold someone responsible for an action if it had physical causes that they could not control, that is, if we interpret their behavior as a symptom. While we are already rethinking of the impact of genes on our behavior, unlinking the brain from it seems too counterintuitive. Although not all, the brain fulfills several accepted philosophical criteria for establishing a causal relationship with behavior.

Nevertheless, neural networks are systems that are open to innumerable external and internal stimuli that can modify their activity almost instantaneously. Our actions reflect a framework of meaningful relationships between biological systems and the environment, articulated in a

historical and social context that frames desires, intentions, beliefs, aspirations, inspirations, and so on. If we assume that cerebral determinism exists, we are assuming the determinism of all of these "universes" (physical, social, cultural, etc.). Otherwise, individual decisions would not be totally predictable because they would depend on the environmental and internal "snapshot" of each moment in which they are taken.

DETERMINISM AND LAW

Based on the idea of cerebral determinism, analytic philosophy has proposed a change to the current punitive system. If an absence of free will is assumed, does it make sense to punish crimes? If behaviors were indeed determined, from a consequentialist point of view, it would be more profitable to promote the good ones than to suppress the bad ones. However, despite assuming that material monism and biological determinism are able to explain our way of being, it does not follow that the law excuses criminal behavior. Explaining behavior does not necessarily imply excusing it.

On the other hand, what should we do if we do not find a biological cause of the behavior? (11) Michel Gazzaniga argues that no neuroimaging pixel can manifest guilt or innocence. From here, it follows that you cannot talk about guilt of the brain. That would be as if the watchmaker blamed the watch. Therefore, the responsibility belongs to people in a context, not to brains. (19)

Daniel Dennett, for his part, believes that the absence of opportunities to decide challenges the very meaning of the nervous system which –according to accepted theories– is born to anticipate obstacles and allow the effectiveness of action and/or movement, and each action is a decision. Therefore, he argues that we are "intentional systems". (20) Likewise, the theories of "predictive processing" to understand cognitive function are hardly compatible with the idea of a total absence of free will. (21,22)

Certainly no one is free in absolute terms. There is always a part of our behavior, of our way of thinking, beyond our control. But the substantial question is, on the one hand, whether we perform acts free of coercion (at least to a reasonable degree), and on the other hand, whether we ever have options when we decide. If the answers are affirmative, we have some degree of moral responsibility. We should move from the freedom/determinism debate to deliberate more pragmatically on the

compatibility of neurobiology and our notion of responsibility. So far, we cannot claim that neuroscientific findings invalidate our perception of will, responsibility, intention, and choice. (23)

In an experiment conducted by Benjamin Libet in 1983, (24) the participants were asked to flex their index fingers rhythmically when they saw an agreed stimulus on a screen while recording their brain activity using electroencephalography (EEG). At the same time, they were looking at a clock to remember the exact moment when they noticed the intention to move the finger. They realized that a potential (*readiness potential*) appeared 300 milliseconds (ms) before they had the conscious experience. Based on the premise that a later event cannot be the cause of a previous event, our intuitive notion of freedom and responsibility was questioned: we would not do what we wanted, we wanted what we did (the brain "knew" that the participants would move their fingers before they themselves knew).

Some experts have noted that the neural signal takes between 50 and 100ms to travel from the cortex to the musculature of the hand, whereas the patient realizes it 200ms before executing the movement: at least, there could be a time span during which we could veto the decision. Other research groups have reproduced and improved the model by showing that the readiness potential is already there before the presentation of the stimulus and, therefore, it may only be a nonspecific alert activity, waiting for the onset of the agreed stimulus. (25) Finally, readiness potential has also been recorded in subjects who perform endogenously initiated movements while undergoing hypnotic suggestion, i.e. –by definition–, without consciously wanting to make them. (26,27)

DETERMINISM AND JUSTICE

Judges and jurors are more inclined to consider the accused "not guilty" if they relate a crime to health problem. (28) For this reason, neuroimaging tests are increasingly used to demonstrate extenuating circumstances or exonerate individuals (29) based on the defendant's ability to understand and/or respect norms, the possibility of choosing (for example: self-defense) and self-control of will (provocation, passion, pathology/pharmacological effect that limits impulse control, etc.).

Nevertheless, one thing is to explain behavior and quite another to excuse it. With infinite knowledge of neuroscience, psychology and so-

ciology, we would probably "understand" the causes of any crime. In this case, would the convictions continue to make sense? In this scenario, maybe we would be, as has already happened with dissatisfaction or with social evils, "medicalizing" the crime, which would simply become a symptom.

Culturally, the symptom is already understood, somehow, as a penalty. We tend to excuse to a greater extent the inappropriate behavior of people considered ill, especially if their illness is related to their behavior. Therefore, it will ultimately depend on the legal system substantiation. Would this mean that, to base the legal system on a deontological model –closer to the USA model–, the penalty is only a payback for the damage caused (retribution)? Does following a consequentialist model mean that the penalties must include the utilitarian practical meaning: "what is best for society"? An example of this model would be to avoid recidivism, where it is fundamental to assess the risk of relapse. Finally, a rehabilitation model implies that penalties must also consider reintegration of the offender into society, which sometimes clashes with the obstacle of the offender's unwillingness to participate in this reintegration. Therefore, a spectrum is drawn between pure revenge and paternalistic overprotection.

Jones et al. (30) make a number of recommendations on the ethical implications of neuroscience research and the application of neuroscience research findings, which we should take into account. Training programs for judges, law enforcement officials and law professors are of great importance in increasing the understanding of neurotechnology and its related scientific aspects (validation of hypotheses, statistics, etc.) (Recommendation-R-1). They also encourage a range of research programs such as teenager decision-making (R4), lie detection technologies (R6), memories (R7) and decision biases (R8); prediction of recurrence of violent acts (R9), especially in young convicts (R11); evaluation and treatment of offenders with addictions, traumatic brain injury, etc. (R10); and precaution against overinterpretation (R14) and misuse (discrimination by ethnic or gender stereotypes) of neuroscientific data (becoming aware of the history of these abuses). The BRAIN Initiative should include an explicit and substantial Ethical, Legal, and Social Implications (ELSI) component, reflected in a dedicated percentage of the overall budget. Therefore, we can conclude by saying that the criminal justice system needs guidance on the neuroscientific technology approach, interdisciplinary work and research to evaluate its limitations with the aim of incorporating neuroscience insights carefully.

NEUROSCIENTIFIC TOOLS IN THE COURTROOM

Functional magnetic resonance imaging is not the first contribution that neuroscience has made to the courts, but it has already been involved in judicial processes for quite a while. The courts had already incorporated expert advice (reports), neuropsychology (with precedent of psychology), neuropharmacology (effect or drug deprivation) and certain neurotechnologies (structural and functional neuroimaging, neurophysiology and molecular genetics). The functional neuroimaging boom, as already noted, allowed the study of brain structure and activation *in vivo*, making it possible to study brain processes *in vivo*. However, fMRI is not an individual digital photo and therefore, hypotheses and experimental designs must be made with caution.[1]

For his part, Stephen J. Morse admits that legal criteria are behavioral, so they consist of an evaluation of mental states or actions. (31) Thus, the problem of translating the neuroscientific mechanism to the traditional psychological standards of law remains. Currently, cerebral neuroimaging has little relevance in legal behavioral criteria. Therefore, some prevention of "brain overclaim syndrome" (overinvolve brain in legal discussions) must be carried out.

Some neuroscience-based lie detection tests have been proposed. Two types of questions are established. On the one hand, *relevant questions* such as: "Did you kill your wife the night of 09/16/2004?". And on the other hand, control questions that are deliberately vague, such as "Before 09/16/2004, did you harm anyone?" The latter are designed for any honest person to answer "yes", but through the thread of the interrogation, they lead the examinee to think that it would be desirable to answer

[1] *To obtain an fMRI scan, the procedure starts when the subject initiates the task to be studied. This task increases neuronal activity and glucose consumption. This involves regional vasodilation and oxygen consumption, causing changes in the deoxygenated hemoglobin percentage. Deoxygenated hemoglobin is paramagnetic and therefore these changes are translated into a hypersignal in MRI (without the need to administer contrast agents). This is the BOLD (Blood Oxygenation Level Dependent) signal.*

Processing the information obtained involves correcting movement artefacts, subtracting the basal patterns from active patterns, subtracting subjects' results from controls' results, etc.; in order to generate a statistical analysis. And finally, the presentation of the activation maps on conventional structural MRI. We could say that what we obtain is a statistical map coded in color superimposed on a conventional high-resolution anatomical image.

"no". When they say "no", it is assumed that the examinee is lying to a "control question" and the fMRI findings for this response are compared with the findings of the "relevant question". However, this method of lie detection based on neuroscience can give rise to *false positives* because it does not read minds or detect the neural signature of the lie, but rather states of cognitive dissonance. What it can do is to potentially answer questions about criminal intent ("*mens rea*") and criminal involvement ("*actus reus*"). (32)

The detection of memories through neuroscience follows a method analogous to the lie detector. Significant items related to crime are presented, such as the gun used to perpetrate the homicide and, on the other hand, control items from the same category but irrelevant, such as other firearms, a knife or a baseball bat. The fMRI BOLD signal shows the activation of the frontal and limbic area (cingulate gyrus and the superior frontal gyrus) when significant items are recognized. The P300 event-related potential (ERP) component is greater when the individual recognizes a significant item among a group of non-significant stimuli (Brain Fingerprinting). This measure helps to establish "*actus reus*" by providing circumstantial evidence of the implication of the subject in the attempted or a related act. However, it does not detect lies, stress or emotion in speech.

NEUROSCIENTIFIC ASSESSMENT OF GUILT

At the most basic level, a structural brain scanner shows damage (tumor, trauma, congenital lesions, pharmacological or toxic effects, etc.) affecting a particular area of the brain that is critical for cognitive control. Recently, important research on the neurological development of adolescents has shown that they pass through a period during which they are more likely to engage in high risk behaviors than in other phases of development or in adulthood. The basic neurological thesis is that areas involved in executive control and decision making (primarily prefrontal regions) develop in asymmetric timing with other major brain regions, particularly those associated with motivational and emotional responses (primarily in the limbic system). This has been named the "imbalance model" of brain development and is relevant to the law because it potentially explains, in part, the adolescent propensity to risky behaviors that lead to higher levels of crime in that population compared with other populations.

Research along these lines has likely influenced legal doctrines regarding criminal punishment of minors, though perhaps not yet at a systemic level. An example of this is found in a study carried out by Peter Ash, (33) where 10 factors are suggested that a forensic evaluator may wish to consider in reaching opinions about an adolescent's culpability.

The not guilty verdict for reasons of mental alienation is rarely used, limited to some cases of sleepwalking, epilepsy or pharmacological effects, among others. (34,26) In cases like these, neuroscience could be of great value in determining whether the accused really does have limitations or predisposition. However, neuroscience is unlikely to lead to radical reforms in legal processes. The changes would surely come gradually, at the rate that our knowledge of the brain is progressing. "The law is a rule-based system and changes in regulations will be needed to accommodate the new information", says Donnelly-Lazarov. (35)

Prosecutors are increasingly willing to consider/accept neuroscientific evidence in a number of countries such as the United States, (36) so we will have to proceed with great caution on how this information is integrated as evidence. We do not rule out, on the other hand, that certain behavioral alterations induced by lesions can be considered, in well-studied and selected cases, as attenuating circumstances. In addition, we may improve our knowledge of these factors in the future, precisely thanks to *cognitive neuroscience*.

NEUROSCIENCE, PENALTY AND REHABILITATION

Once the culpability of the accused has been determined, an appropriate penalty will be imposed for the crime committed and the particular circumstances of the case. Therefore, the main objectives of a trial are to compensate for damage and rehabilitate the accused. This reintegration, in theory, would produce a double benefit: individual, for the accused, and social, reducing recidivism. From this it follows that if we can predict the probability of success of the reintegration or the risk of criminal reoccurrence, we would be better able to dictate penalties in each specific context. In this sense, neuroscience has some potential to provide information that would be useful for such predictions. Thus, it has been proposed that lower levels of anterior cingulate cortex activity (associated with inhibition and behavior regulation) are associated with higher rearrests rates. (37)

Regarding adolescents, we should be particularly aware of these facts. Firstly, the frontal lobes continue to mature until the mid-twenties, and possibly beyond them. Secondly, this means that the neural circuits involved in functions such as impulse control and decision making are the last thing to mature. What is more, the reward circuit in the adolescent brain is hypersensitive. These results taken together help to explain what we think of the stereotyped behavior of adolescents: taking risks, making bad decisions, trying to impress their friends, etc.

Recently, the US Supreme Court has begun to use two neuroscientific criteria in adolescent trials. On the one hand, having less capacity for self-control, their actions are less morally censurable, as they have less control of their propensity towards risk behaviors. On the other hand, they are supposed to have a greater likelihood of reintegration. Studies on inhibitory control with *go/no-go (GNG)* tasks have shown that while adolescents can often control their impulses as well as adults in a neutral context, in emotional contexts the impulse control is severely restricted. (38) However, we must be very careful when using these arguments because they could also be used to justify the reduction or limitation of some adolescents' rights like driving, drinking or having an abortion.

Assuming this attitude regarding adolescents' behavior, does this mean that they will simply be "healed" by age? It seems controversial to say this. A much more useful measure for legal effects would be an individual development index that provides some indication as to the individual's cognitive propensity to risk behaviors. This is currently unavailable. It is well established in the literature that there are significant individual differences between adolescents in prefrontal development. If the key issue for low-age criminality were "the adolescent brain is immature", we would expect high homicide rates at these ages in different countries. This is not the case and therefore other relevant factors are suggested to be involved. (39)

Practically all legal systems are based on the premise that human beings can act by their own volition, guided by their intentions. Therefore, they are responsible and punishable according to their actions. Nevertheless, some interpretation of recent neuroscientific findings challenges this accepted framework. The experimental models, such as Libet's experiment, use a hyper simplified conceptualization of freedom of choice, which therefore has little impact on the law. (24)

The use of neuroscientific techniques to determine punishment or appropriate rehabilitation for a particular crime also has a number of

limitations that must be taken into account. Neuroimaging findings have yet to prove that they bring added value to risk assessment for relapse using classic behavioral methods, which do apply at the individual level. The use of biological markers of relapse without consent in trials can be questionable, at least from certain points of view.

To be applicable to the legal system, cognitive neuroscience should consider how free will –or its different manifestations– is conceptualized in the legal system. It should also consider designing more appropriate experiments that incorporate these concepts. How could neuroscience help to establish the guilt of a serial killer in contrast –for instance– with execution practiced by an executioner?

Another aspect found on the list of limitations to these neuroscientific uses is the existence of differences between the legal systems in different countries or states, such as admissibility of a witness, defense for mental disorder (in some countries it does not exist) or the rights against self-incrimination, to mention only a few. One must also consider whether neuroscience is –or may be– relevant in the application of the law in criminal cases. From what we have seen so far, neuroscientific research on the neural basis of the will focuses on very simplified concepts of intention and intentionality. Moreover, the relevant mental state was used in the past for legal purposes, and to be able to approach this issue from the neuroscience perspective does not currently seem feasible.

Apart from limitations to its uses, we must also mention the limitations of neuroscientific technology itself. The cause-effect relationship cannot be lightly assumed. Just as the coincidence of two facts in time and space does not causally relate them, at least not necessarily (inverse inference); if you think about apples you activate an "X" area of the brain, this does not mean that every time you activate "X" you are thinking about apples. A published study "deduced" that watching television (TV) improved mathematical abilities because the research subjects activated the same brain regions when they solve arithmetic problems as they did when they watched TV. (40)

ADMISSIBILITY OF NEUROCIENTIFIC TESTS

The admission of neuroscientific evidence in trials can only be effective if a judge admits them. Therefore, if the scientific community has not yet accepted certain technologies as reliable, it is highly unlikely that a judge

will admit tests based on them. The *Daubert criteria* offer 5 factors to help judges assess whether the techniques used by the experts are reliable. We must keep in mind that the expert reports are not binding, so the decisions that are taken based on them depend on the criteria of the jury and the judge. The first criterion states that they must ask whether that technology has been or can be tested, whether it has been examined through the scientific method. The second one asks for it to be submitted to a prior review. The third criterion requires that the techniques used must have established standards. The fourth one says that the potential error rate must be known. And the final one asks whether the scientific community generally accept it.

It is very useful for judges to have some factors to assess whether a technique can be used in court. However, the admissibility of neuroscientific evidence presents four obstacles that must be considered: external validity, detection at an individual level (called "the G2i problem"), potential overvaluation and usurpation of the jury's role.

Firstly, the obstacle of external validity (ecological) is evident in the fact that the data on which these technologies are based have been generated in the laboratory and therefore cannot be directly extrapolated to real life, which is dealt with by law. Lie detection in fMRI seems to overlook that many of the regions involved in deception are also under executive control. It is also assumed that lying is cognitively more complex than telling the truth, recruiting areas of complex cognitive control; but it is even more so outside the laboratory. As for lie detection through ERP (P300 wave), crime simulations present highly selected stimuli, almost without "junk" information, and this is not the situation in the real world. On the other hand, several experts point out that neuroscientific evaluation, although not perfect, may have a lower error rate than classic forensic evidence; which is usually admitted in courts in spite of not negligible margins of error. In the same way, jurors can also make mistakes in the difficult task of determining the veracity of witnesses' statements.

Secondly, the problem of detection at the individual level is that there is no proof that neuroscientific findings at the group level can be extrapolated directly to the individual level, and this would prevent use of the datum as an evidence. The fact is that courts more readily accept these data in the context of trials (punishment) than in determining individual responsibility for crime (guilt), although it is important to consider that the legal use of neuroscientific evidence does not require the same level of certainty that scientific demonstration and/or publication does (i.e.,

95% confidence that results are not random). This affects fMRI –not so much P300 ERP– since it has shown more reliability at the individual level. One of the future research challenges, therefore, should be to improve data at the individual level and increase the realism of laboratory models.

Thirdly, overinterpretation is a problem caused by the fact that the striking fMRI colors may favor unwarranted inferences (not well-founded inferences). Concern over the power of suggestion that the neuroscientific tests generate in the minds of judges and jurors is based on the fact that there is a risk that judges, jurors and the public interpret these tests as legitimate by definition solely because of their visual impact and a kind of technological fascination. Non-scientists can overestimate the applicability of weak results and/or underestimate the limitations by extrapolating to the individual case. On the one hand, lawyers, in the interest of their clients, will always seek the widest possible interpretation in their favor. On the other hand, judges should receive specific training since it is their duty and responsibility to decide on the admissibility or burden of these tests. This is why neuroscientists must explain the limitations of their studies in publications, precisely to avoid misuses and abuses based on them, and try to adapt experimental models to the legal context in real life. (9) Procedural guarantees require judges to exclude relevant evidence "if their test value does not outweigh the unfair prejudice profile that this can lead to". (41)

Fourthly and finally, at least in the United States, evidence of credibility evaluation seems to impinge on the role of the jury, which until now has served as sole evaluator of the credibility of witnesses. But what if it turns out that technology is more reliable than the jury? In any case, regardless of its admissibility in the trial, the usefulness of scientific evidence should be explored during the previous investigation process.

CONSTITUTIONAL GUARANTEES

Does mind reading threaten fundamental rights? Are our minds protected like our homes? Is it constitutional to order a "brain record"? According to the 4th amendment to the United States constitution, the individual is protected from unreasonable records or invasions of privacy. It seems that people may have privacy expectations for their brain waves. However, does ordering a memory test from a suspect force him/her

into self-incrimination? The 5th amendment protects people from being forced to testify against themselves, so it seems that they would be protected against such practices. It remains to be determined whether detection of lies and memories through neurotechnology is considered a communicative act or they are only considered as unprotected brain responses, similar to biological samples.

Lie or memory detection is a challenge to our freedom of thought. The 1st amendment, in the United States, protects freedoms of expression, worship, press, petition and meeting. Therefore, theoretically, we should not be condemned for what we think, but for what we do. To a certain extent, thought has remained free in severe dictatorships, among other reasons because dictators did not have the technological measures to control it; they have "only" had the option of torture to inquire about thoughts.

In neurology, every day more than one –and more than two– "spectacular" brain images are seen that have no clinical correlation, and it is not true that there is a one-to-one correspondence between brain injury and social danger or risk of crime. Not all individuals with frontal injuries, not even all those who develop an antisocial personality disorder, commit crimes or harm others. Currently, it is virtually impossible to ensure that a particular MR response in an individual test is unequivocally linked to socially abnormal and/or aggressive behavior.

CONCLUSIONS

Taking all the above into account, we can conclude that it is not at all clear to what extent neuroscientific tests, which are already being presented in court, favor or contaminate the correct administration of justice. Neither is it clear how to address the intersection of technologies and the legal system with the aim of creating an even fairer, more rational and effective criminal justice system.

However, neuroscience has the potential –perhaps not yet the "power"– to influence many legal issues by improving witness interviewings and police interrogations (lie detection) or by improving the selection of jurors through disqualification of those with prejudices or biases, if possible. It can also help to better approximate the intentionality of the accused, prediction of their future behavior and the prospects of reintegration into society. Nevertheless, these predictions cannot be made based

solely on neuroscientific data, as contextual factors are key determinants of human behavior.

The problem is to transfer the theoretical validity of neuroscientific evidence from the laboratory or clinical world directly to the courts and to show that neural correlates of deception or other forms of cognition have legal relevance. Such evidence will –therefore– require humility, prudence and work, which can be seen reflected in experimental models that connect, individually, colors or waves and behavior, within a socio-cultural framework of coexistence.

Finally, we can take into account the outcome of the case of Mr. Weinstein, described above. He refused surgical treatment for his cyst and presented exemplary conduct in prison. Consequently, he obtained a considerable reduction in his sentence. He was released with optimum integration into the community, with no indication of violence or disinhibition. (39)

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